



# The Power of the Pixel- A Paradigm for Studying Disease Vector's Habitats & Life Cycles Using NASA's Remote Sensing Data & GEOS Infrastructure

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# Earth System Science



Sun- Earth  
Connection

Climate Variability  
and Change

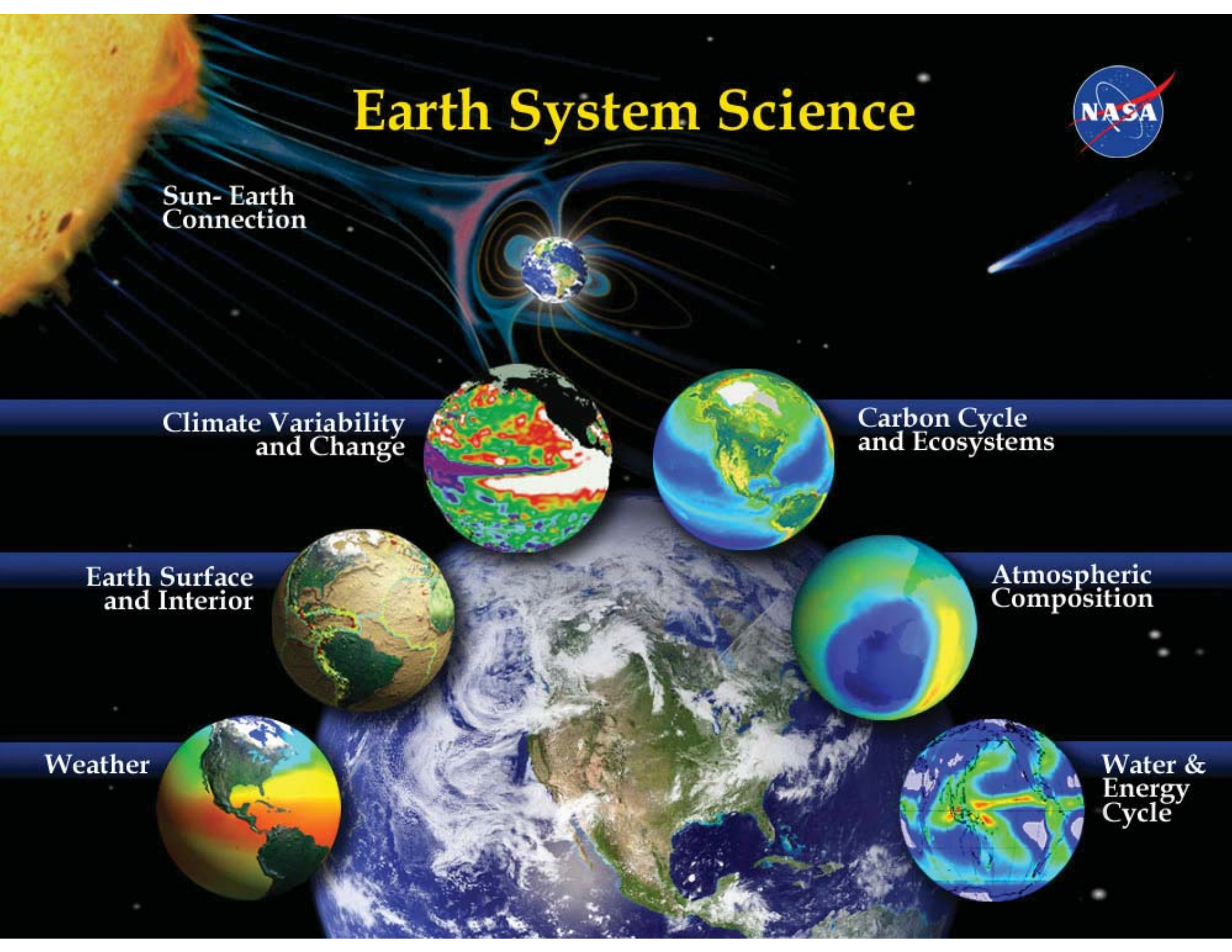
Carbon Cycle  
and Ecosystems

Earth Surface  
and Interior

Atmospheric  
Composition

Weather

Water &  
Energy  
Cycle





# **NASA Applied Sciences Program Mission Statement**

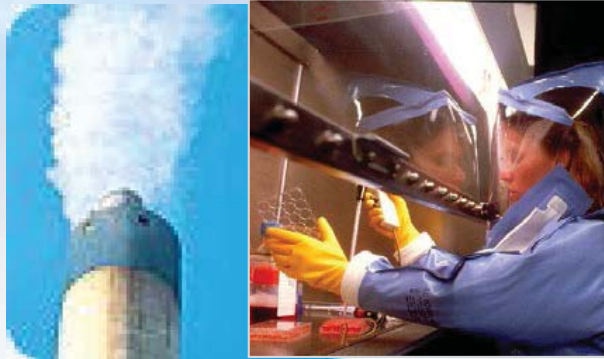
**Advance the realization of societal and economic benefits from NASA Earth science by identifying societal needs, conducting applied research and development, and collaborating with application developers and users.**





# Applied Sciences Program

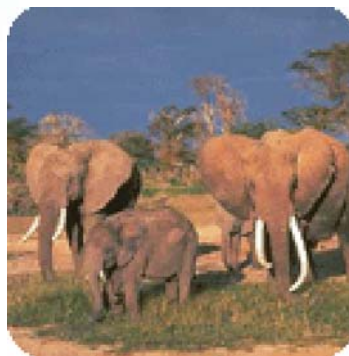
## *Four Program Elements*



**Public Health  
Air Quality**



**Disaster  
Management**

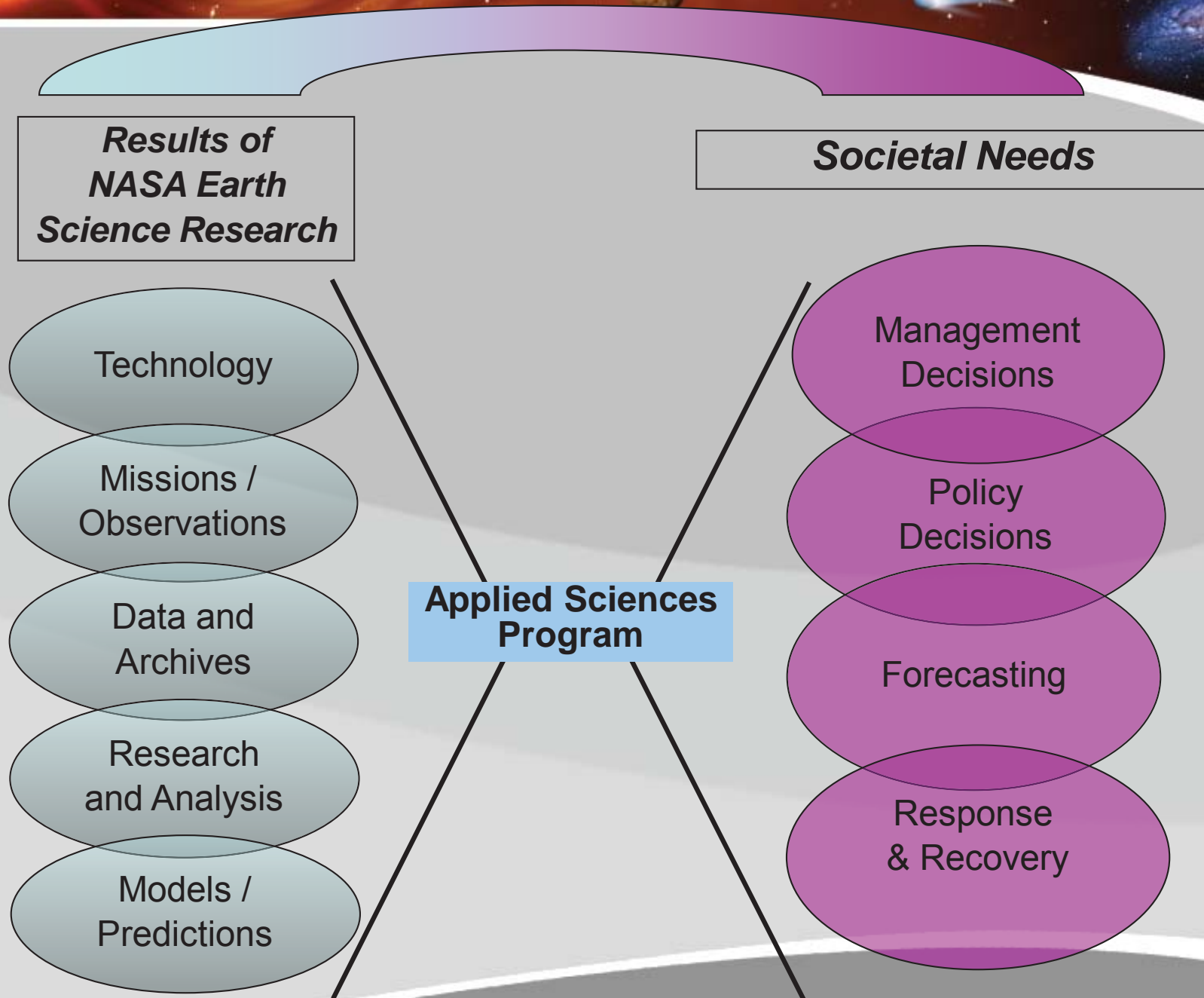


**Ecological  
Forecasting**



**Water  
Resources**

# NASA Applied Sciences Architecture



# Focus Areas of Public Health

The Public Health application area focuses on Earth science applications to public health and safety, particularly regarding ***infectious disease, emergency preparedness and response, and environmental health*** issues. The application explores issues of toxic and pathogenic exposure, as well as natural and man-made hazards and their effects, for risk characterization/mitigation and improvements to health and safety.





Figure 3-4 Photograph of Gaspard Felix Tournachon (1820-1910), the famous Parisian photographer. He called himself Nadar. Here he is seen kneeling in a fragile balloon gondola. He obtained the first aerial photograph from a balloon in 1858 near Paris, France, and patented the aerial survey as we know it today. Unfortunately, the first aerial photograph did not survive (© Roger-Viollet Paris, France; used with permission).



Figure 3-5 A portion of an aerial photograph of downtown Boston, MA, obtained by aeronauts James W. Black and Samuel A. King from a tethered balloon at an altitude of 1,200 ft on October 13, 1860. It is believed to be the first aerial photograph taken from a captive balloon in the United States and the earliest aerial photograph still in existence. It was obtained using a wet collodion plate (used with permission of the Smithsonian Institution, Washington, DC; #3B-15472).



Gaspard Tournachon, AKA  
Nadar 1858

Boston, MA 1860, Black & King

# NASA Earth Science Missions

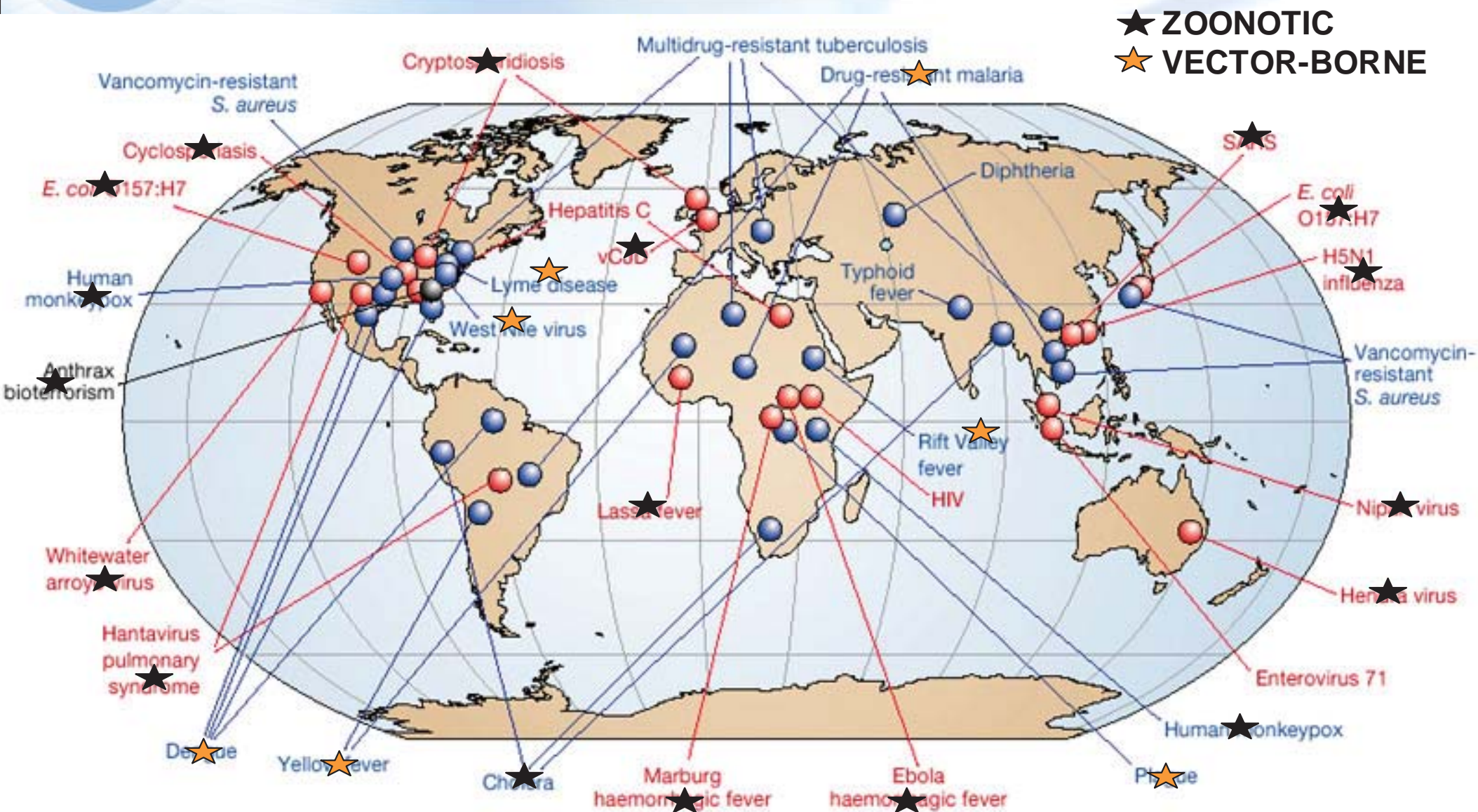
## *Current & Planned*

- Formulation
- Implementation
- Primary Ops
- Extended Ops





# Global Emerging Diseases\*



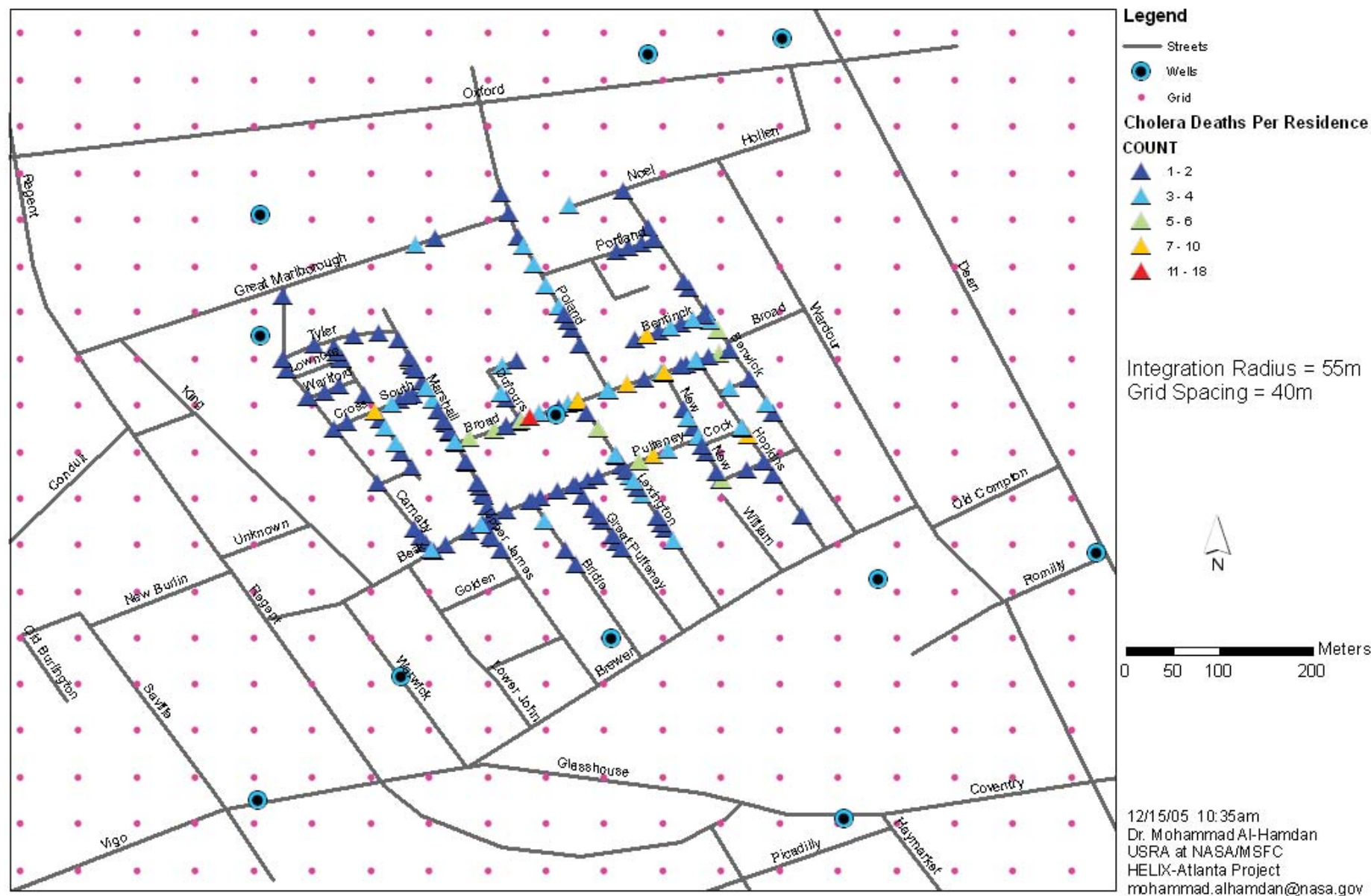
EMERGING  
RE-EMERGING

\* Modified from Morens et al. 2004 *Nature* 430:242



# Public Health Surveillance

## Cholera Deaths Soho, London August-September, 1854



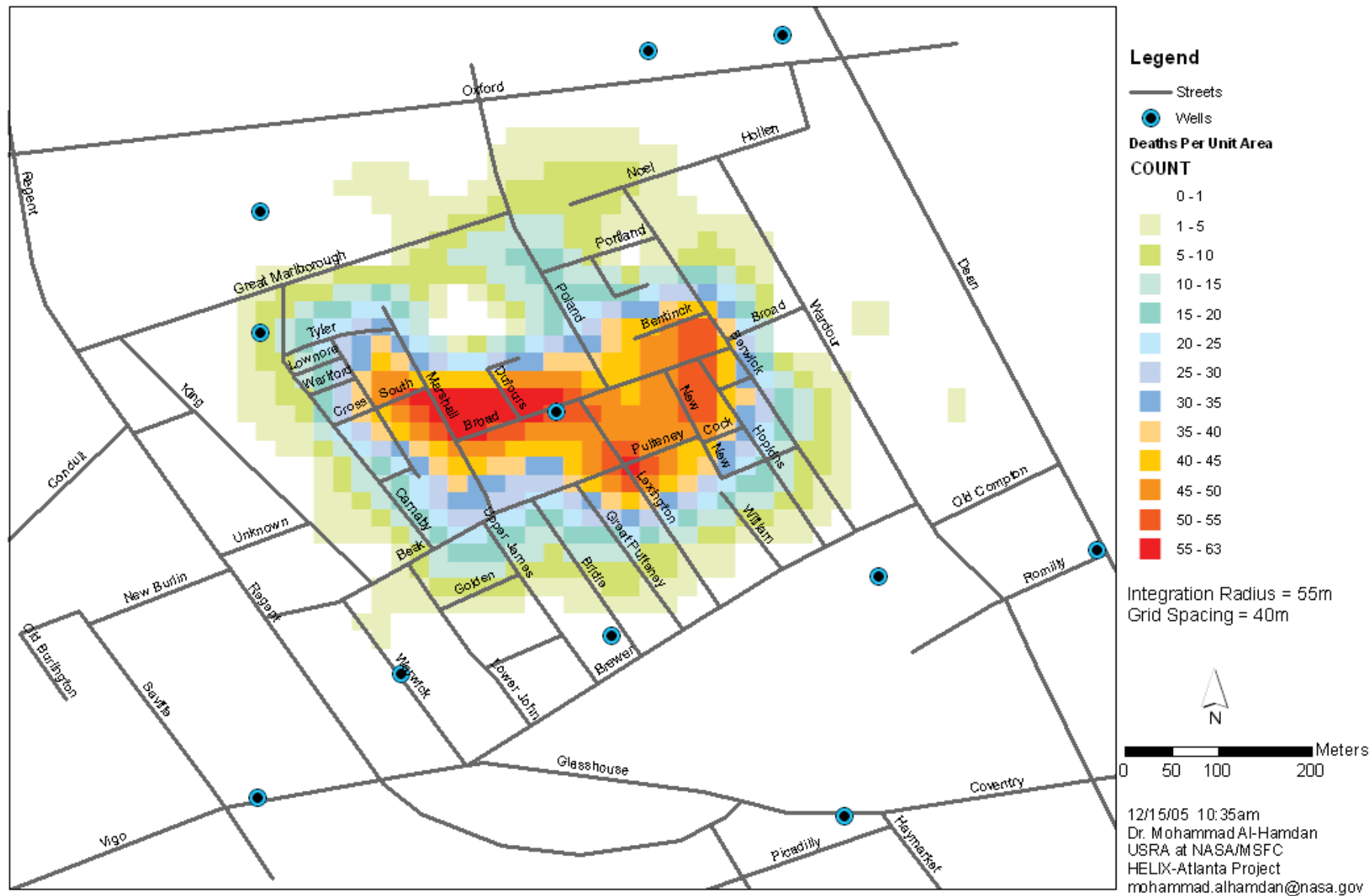
\*Original data were published by C.F. Cheffins, Lith, Southampton Buildings, London, England, 1854 in Snow, John. On the Mode of Communication of Cholera, 2nd Ed, John Churchill, New Burlington Street, London, England, 1855.

\*\*Digital Data of Streets, Wells, and Deaths Residences which were used to create this surface were downloaded from the UCLA Department of Epidemiology Website at <http://www.ph.ucla.edu/epi/snow.html>.



# Public Health Surveillance

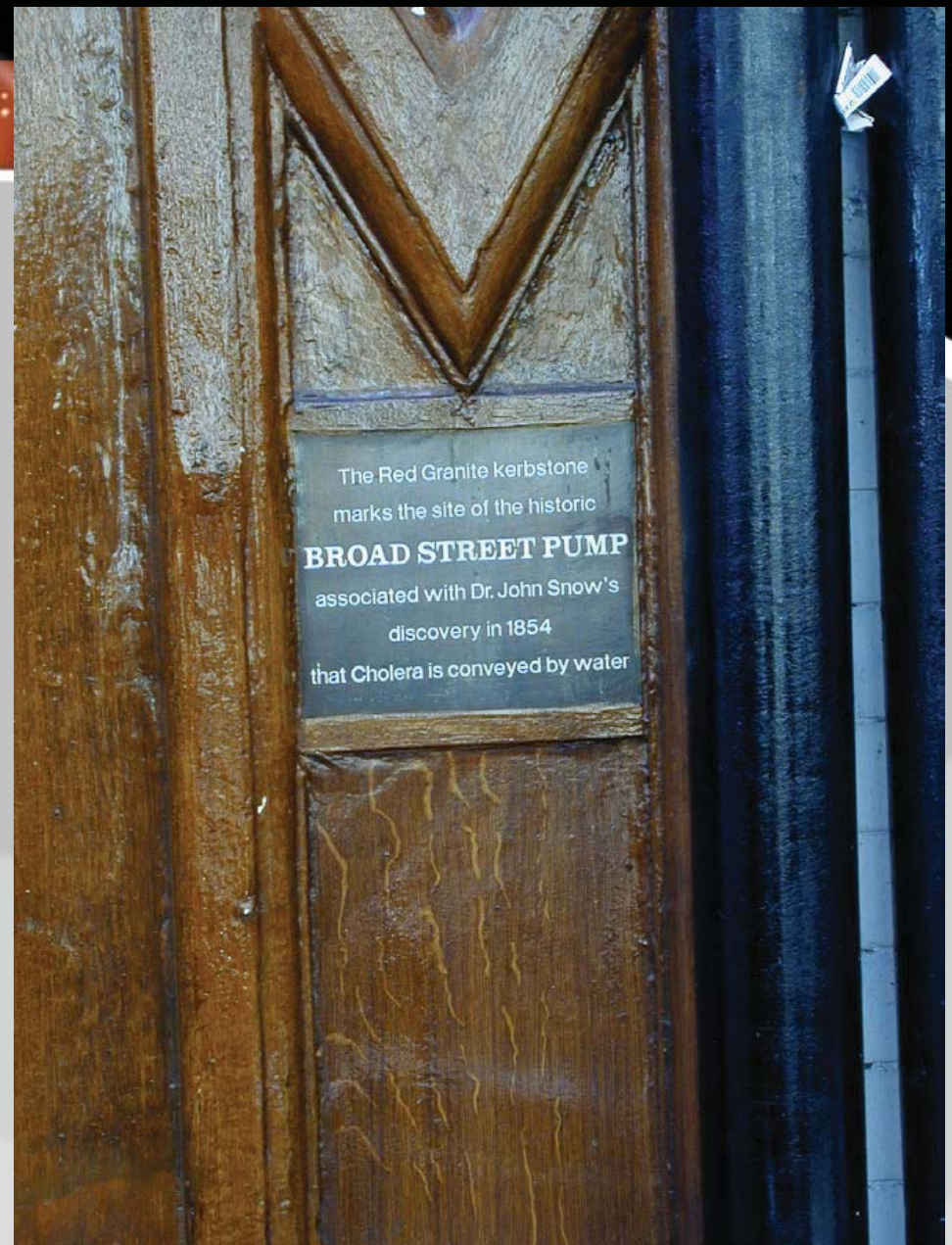
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\*\*Digital Data of Streets, Wells, and Deaths Residences which were used to create this surface were downloaded from the UCLA Department of Epidemiology Website at <http://www.ph.ucla.edu/epi/snow.html>.





Courtesy: Dr. Jeff Luvall, NASA/MSFC



**“Neglected Tropical Diseases,**  
**“Maladies Tropicales Négligées,**



**Succès ignorés,**  
**Nouvelles opportunités”**



World Health  
Organization

**Hidden successes,**  
**Emerging opportunities”**



WHO is currently focusing on **14** neglected tropical diseases:

- Buruli ulcer
- Chagas disease
- Cholera/Epidemic diarrhoeal diseases
- Dengue/dengue haemorrhagic fever
- Dracunculiasis (guinea-worm disease)
- Endemic Treponematoses (yaws, pinta, endemic syphilis...)
- Human African trypanosomiasis
- Leishmaniasis
- Leprosy
- Lymphatic filariasis
- Onchocerciasis
- Schistosomiasis
- Soil-transmitted helminthiasis
- Trachoma
  - Yaws
  - Rabies



# Neglected Diseases in Latin America & Caribbean

Dengue

Schistosomiasis

Dust induced Asthma

Soil-transmitted Helminthiasis

Chagas

TB

Filariasis

Fascioliasis

Triatomines (Reduviidae: Triatominae)

Leishmaniasis

Leprosy

Hookworm

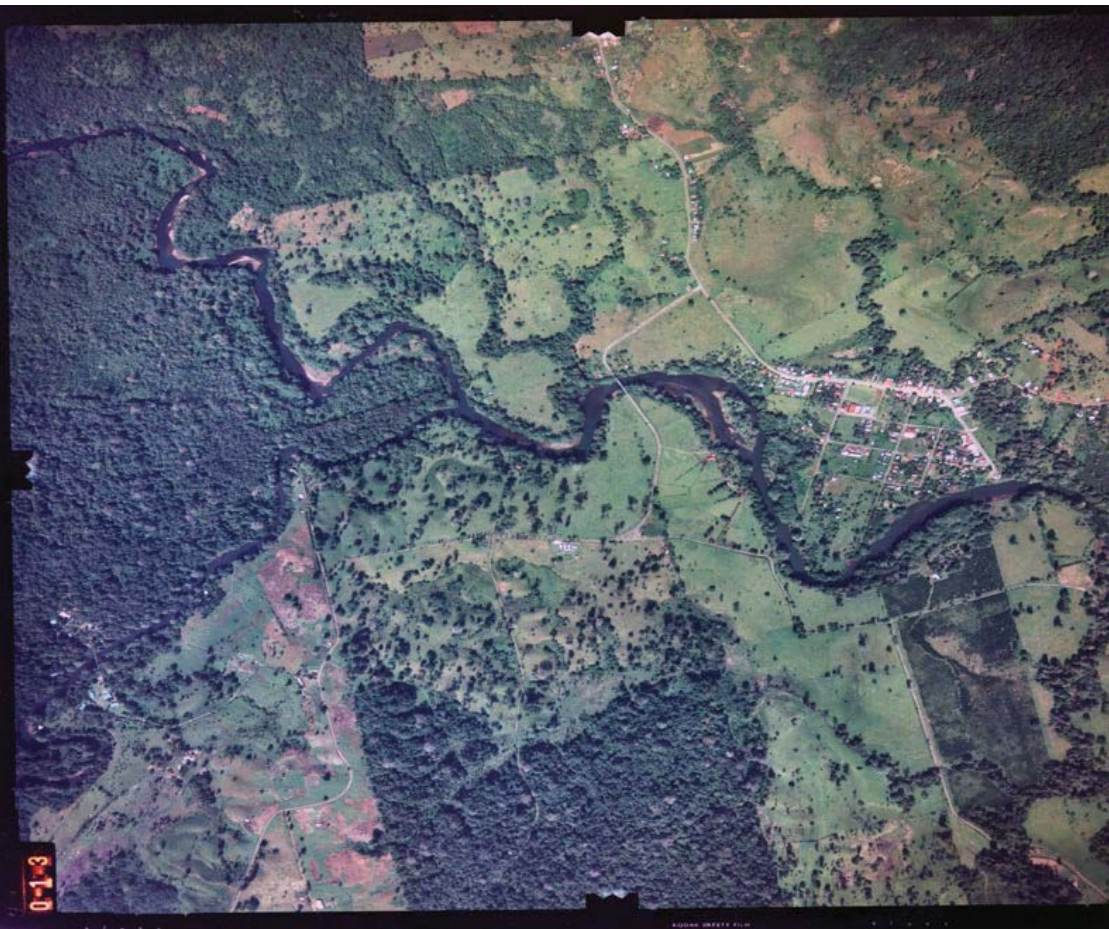


## Ranking of NTDs in LAC by Prevalence and Distribution

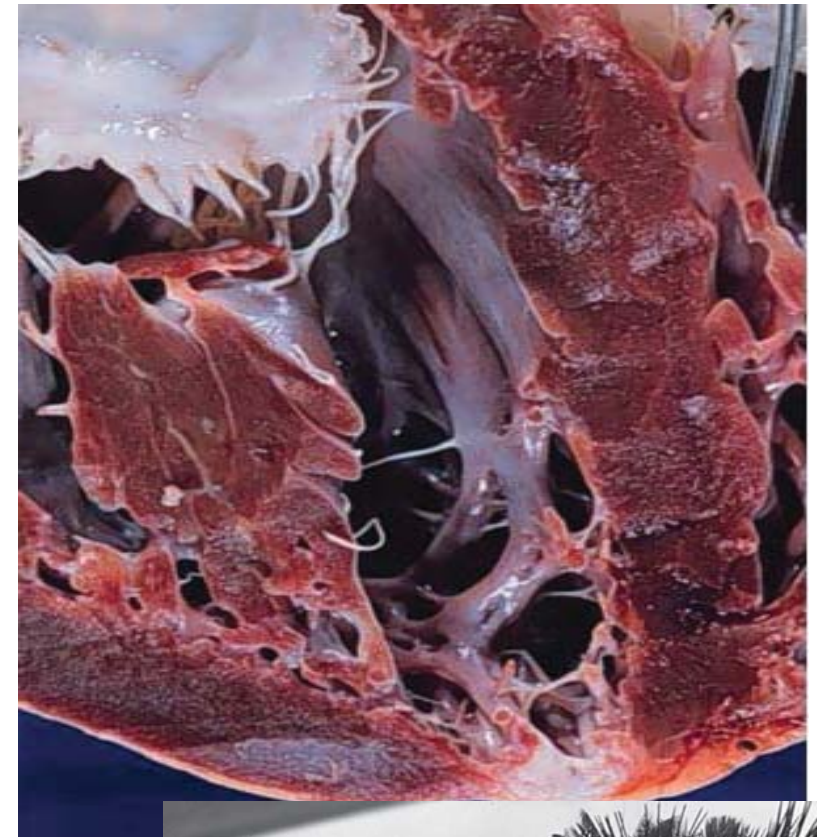
Disease	Population Currently Infected in LAC	Population At Risk in LAC	Major Vulnerable Populations or Geographic Areas	Number LAC Countries Infected	Percentage of LAC Population Infected (% Poor People Infected)
Trichuriasis	100 million	523 million	Poor rural & urban slums	27	17.8% (46.9%)
Ascariasis	84 million	514 million	Poor rural & urban slums	27	15.0% (39.4%)
Hookworm	50 million	346 million	Poor rural	26	8.9% (23.5%)
Chagas disease	8–9 million	25–90 million	Poor rural & urban slums	13	1.6% (4.1%)
Schistosomiasis	1.8 million	36 million	Poor rural	4 with >1,000 cases	0.3% (0.8%)
Blinding trachoma	1.1 million	ND	Poor rural	3	0.2% (0.5%)
Lymphatic filariasis	720,000	8.9 million	Urban slums & poor rural	7	0.1% (0.3%)
Dengue	552,141 reported in 2006	ND	Urban slums	23	0.1% (0.2%)
Cysticercosis	400,000	75 million	Poor rural	15	<0.1% (0.2%)
Cutaneous (CL) and visceral (VL) leishmaniasis	62,000 CL 5,000 VL	ND	Urban slums & poor rural	18	ND
Leprosy	47,612 new cases	ND	Poor rural & urban slums	22	<0.1% (<0.1%)
Onchocerciasis	64 new cases in 2004	515,675	Poor rural	6	<0.1% (<0.1%)
Jungle yellow fever	86 new cases in 2004	ND	Jungle & urban slums	4	<0.1% (<0.1%)



P. J. Hotez, M. E. Bottazzi, C. Franco-Paredes, S. K. Ault, and M. R. Periago. 2008  
 The Neglected Tropical Diseases of Latin America and the Caribbean: A Review of Disease Burden and Distribution and a Roadmap for Control and Elimination. PLoS Negl Trop Dis. 2008 September; 2(9): e300.



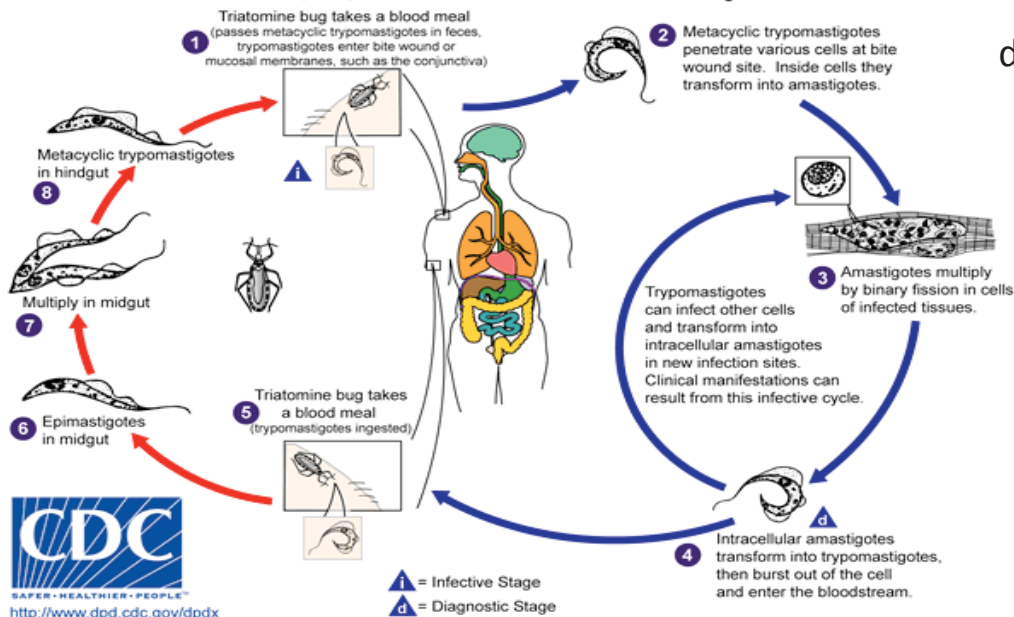
a



e

### Triatomine Bug Stages

### Human Stages



1

3

b



2

d

c

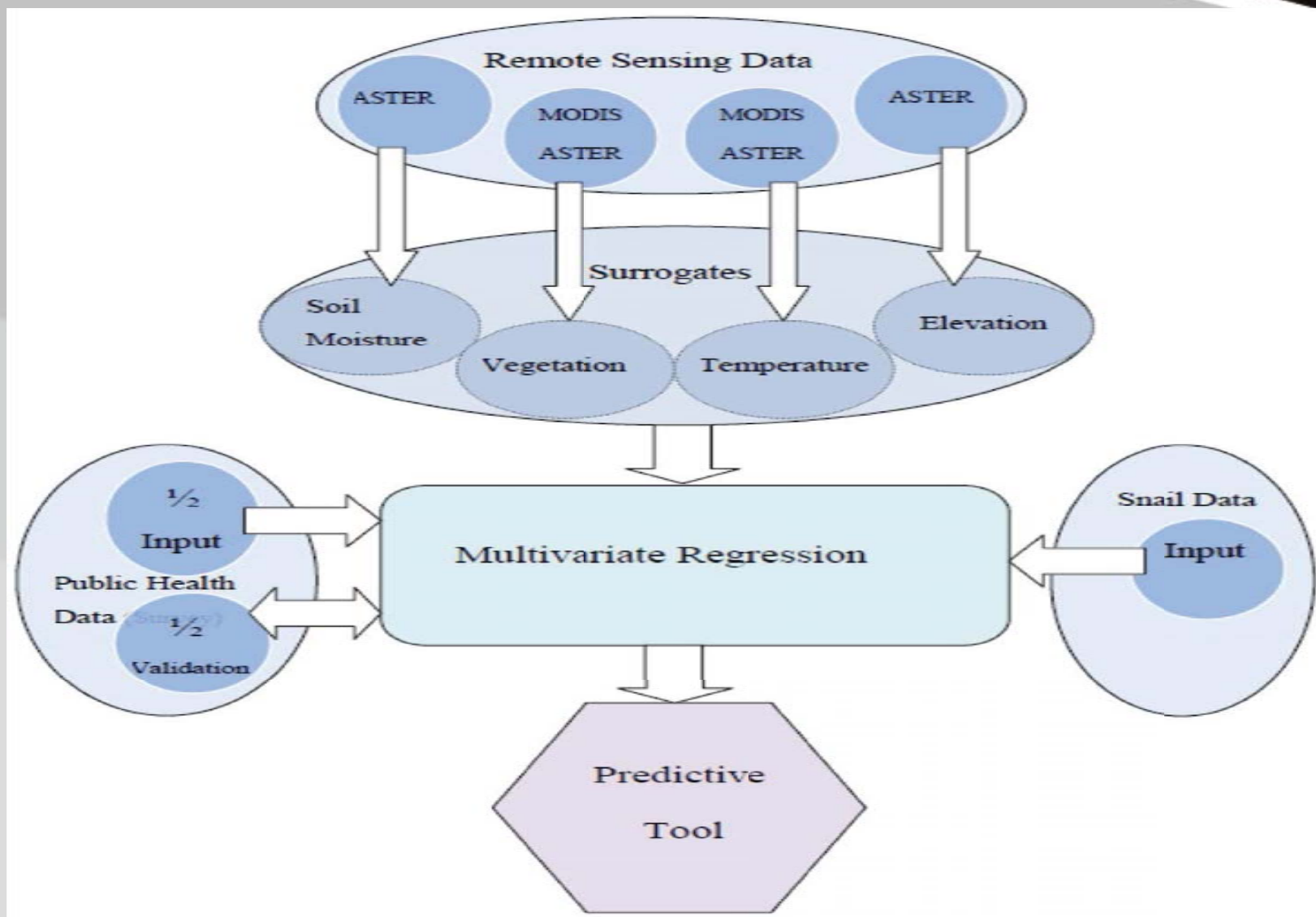


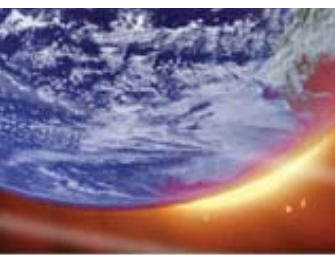
## Major NTD Target Sub-Regions and Unique Ecologies

Scenario	Sub-Region	NTDs	Indigenous Populations	Co-Factors <sup>a</sup>
1	Southern cone of South America	Chagas, leishmaniasis, cysticercosis, echinococcosis, hemorrhagic fevers	+	Cattle ranching, minifundios, urban migration
2	Chaco (Bolivia, Paraguay, Argentina)	Chagas, leishmaniasis, STH	+++	Cattle ranching, minifundios, animal husbandry
3	Andean region (Altiplano or Highland)	Fascioliasis, Chagas, leishmaniasis, plague, bartonellosis, STH, cysticercosis, echinococcosis, ectoparasites	++++	Minifundios, urban migration
4	Amazonian basin	Chagas, leishmaniasis, STH, onchocerciasis, leprosy, trachoma, ectoparasites	++	Deforestation, mining, guerillas, urban migration, indiscriminant colonization
5	Eastern Brazil	STH (esp. hookworm) schistosomiasis, Chagas disease, leishmaniasis, LF (NE only), echinococcosis, leprosy, leptospirosis	++	Cattle ranching, deforestation, minifundios, urban migration, monoculture
6	North Pacific of South America	STH, cysticercosis, leishmaniasis, onchocerciasis, echinococcosis	++	Deforestation, gold mining, guerillas
7	Caribbean basin	STH, schistosomiasis, LF, leprosy, leptospirosis, fascioliasis	+	Economic dependence on tourism, deforestation, urban migration
8	Central America and Panama	STH, leishmaniasis, Chagas, onchocerciasis, cysticercosis, leptospirosis	+++	Deforestation, desertification, migration
10	South and Central Mexico	STH, Chagas, cysticercosis, leishmaniasis, trachoma, onchocerciasis	+++	Deforestation, migration
11	Northern Mexico	STH, Chagas, cysticercosis, leishmaniasis	++	Desertification, migration



P. J. Hotez, M. E. Bottazzi, C. Franco-Paredes, S. K. Ault, and M. R. Periago. 2008  
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### Calibration

(see also: <http://mcst.gsfc.nasa.gov/>)

- MOD 01 - Level-1A Radiance Counts
- MOD 02 - Level-1B Calibrated Geolocated Radiances
- MOD 03 - Geolocation Data Set

### Atmosphere

(see also: <http://modis-atmos.gsfc.nasa.gov/>)

- MOD 04 - Aerosol Product
- MOD 05 - Total Precipitable Water (Water Vapor)
- MOD 06 - Cloud Product
- MOD 07 - Atmospheric Profiles
- MOD 08 - Gridded Atmospheric Product
- MOD 35 - Cloud Mask

### Land

(see also: <http://edcdaac.usgs.gov/dataproducts.asp> and <http://modis-land.gsfc.nasa.gov/>)

- MOD 09 - Surface Reflectance
- MOD 11 - Land Surface Temperature & Emissivity
- MOD 12 - Land Cover/Land Cover Change
- MOD 13 - Gridded Vegetation Indices (Max NDVI & Integrated MVI)
- MOD 14 - Thermal Anomalies, Fires & Biomass Burning
- MOD 15 - Leaf Area Index & FPAR
- MOD 16 - Evapotranspiration
- MOD 17 - Net Photosynthesis and Primary Productivity
- MOD 43 - Surface Reflectance
- MOD 44 - Vegetation Cover Conversion

### Cryosphere

(see also: <http://nsidc.org/daac/modis/index.html>)

- MOD 10 - Snow Cover
- MOD 29 - Sea Ice Cover

### Ocean

(Details about ocean products are best obtained by going to: <http://oceancolor.gsfc.nasa.gov/>)

- Angstrom Exponent
- Aerosol Optical Thickness
- Chlorophyll a
- Downwelling diffuse attenuation coefficient at 490 nm
- Level 2 Flags
- Photosynthetically Available Radiation
- Particulate Inorganic Carbon
- Particulate Organic Carbon
- Sea Surface Temperature Quality
- Sea Surface Temperature Quality - 4um
- Remote Sensing Reflectance
- Sea Surface Temperature
- Sea Surface Temperature 4um

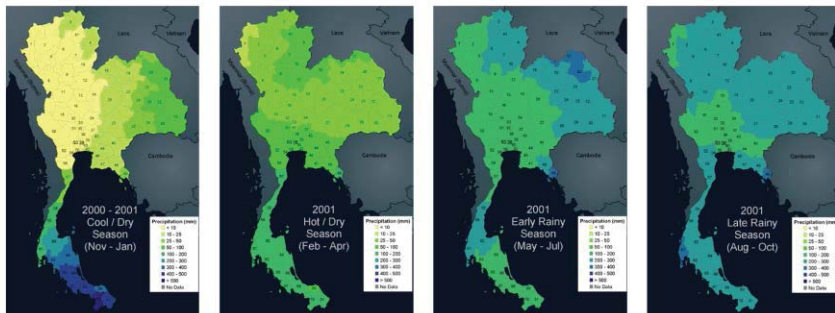


# Collaboration with DOD, USGS, USAID, and Columbia U. on Malaria

**USAID**  
FROM THE AMERICAN PEOPLE



**USGS**  
science for a changing world



Precipitation is one of the main environmental determinants that promotes malaria transmission. The precipitation distribution in provincial resolution, based on NASA TRMM observations, is shown for the four Thailand season from 2000 to 2001.



This image shows vegetation density (NDVI) over Africa in May 2008. By closely monitoring vegetation in regions affected by increased rainfall, scientists can identify areas at increased risk for outbreaks of malaria.

**Problem:** Malaria kills up to 3 million people yearly worldwide, many of whom are children. In addition, malaria costs African nations approximately \$12 billion in economic productivity. The health and economic consequences of malaria make it a destabilizing phenomenon. Accurate characterization of malaria risk is important because of its impact on US military and humanitarian personnel and operations. Global climate change may expand malaria risk areas to new locales, particularly higher altitudes.

**Solution:** NASA and DOD (through GSAT) and USGS, USAID, and Columbia U. (through MEWS) are partners in utilizing environmental parameters such as precipitation, temperature, and vegetative cover to better characterize malaria transmission risks.

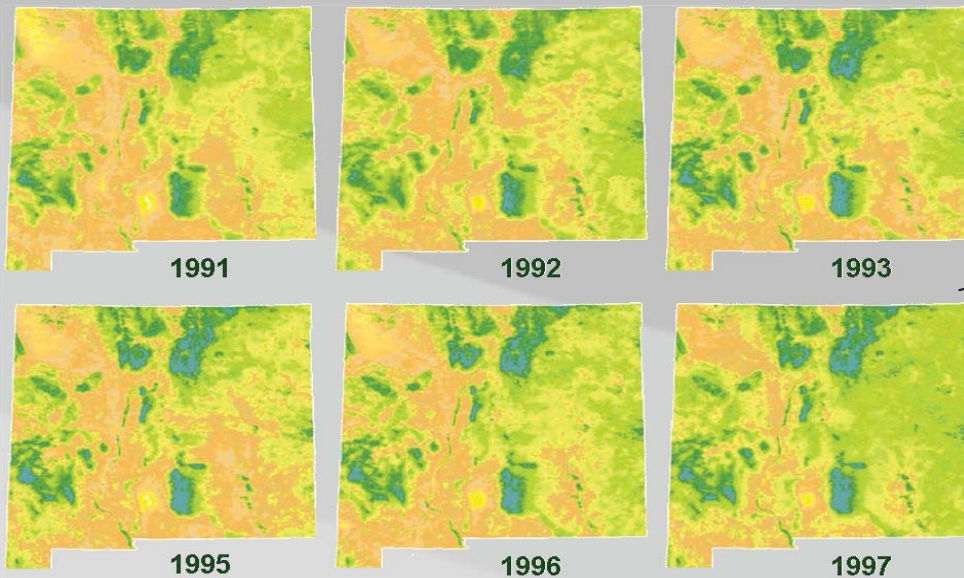
**NASA Research Results:** Model predictive capabilities and observations from NASA Earth-observing satellites such as Terra, Aqua, and TRMM.

**Status:** Current and future malaria risks have been forecast in a quantitative, dynamic, and accurate manner in Thailand, Afghanistan, and Indonesia. Rolling 10-day rainfall anomaly products and 8-day Vectorial Capacity products are produced for Africa and these data are disseminated on the web as both graphic and GIS products (available at the ADDS website: <http://earlywarning.usgs.gov/fews/africa/index.php>).

# Collaboration with the CDC ArboNET on Plague



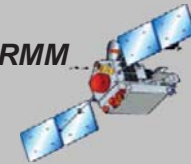
Vector habitats, seasonal lifecycle variations, migration pressure from rainfall, soil moisture, vegetative cover, surface temperature, elevation, and slope.



Landsat 7

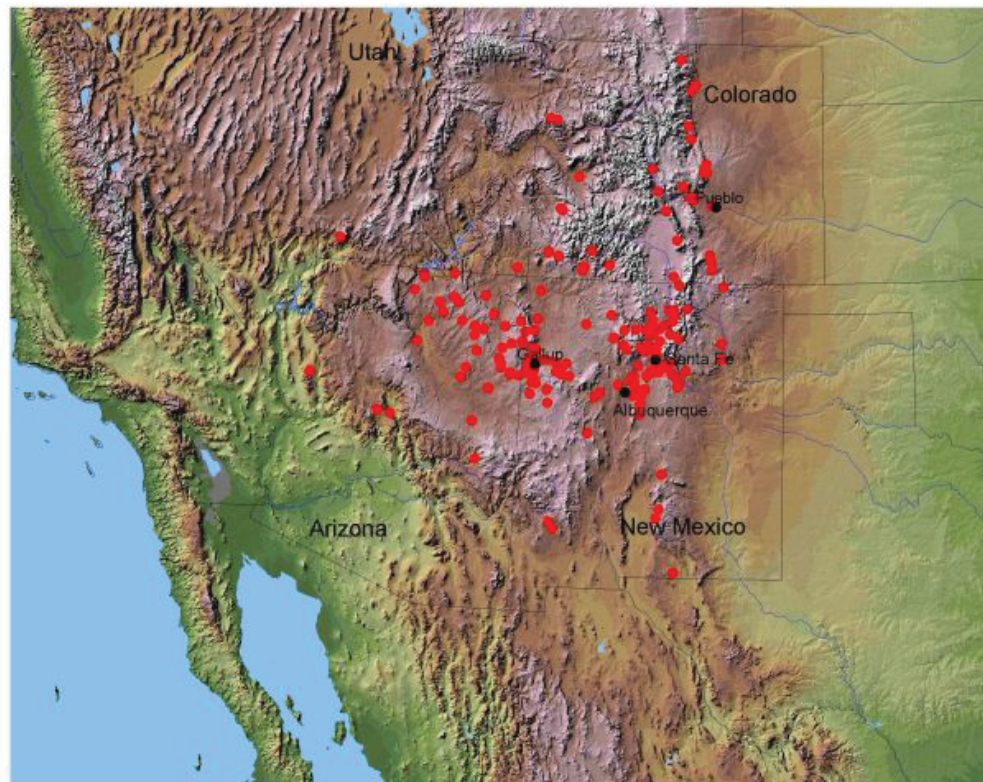


TRMM



# ArboNET/Plague Results

Shaded elevation and Plague cases, 1980-2002

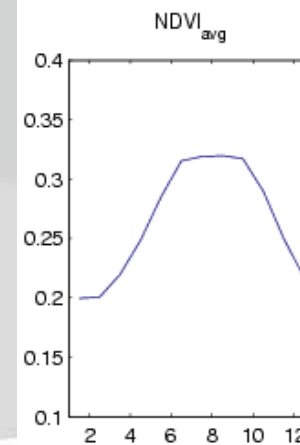
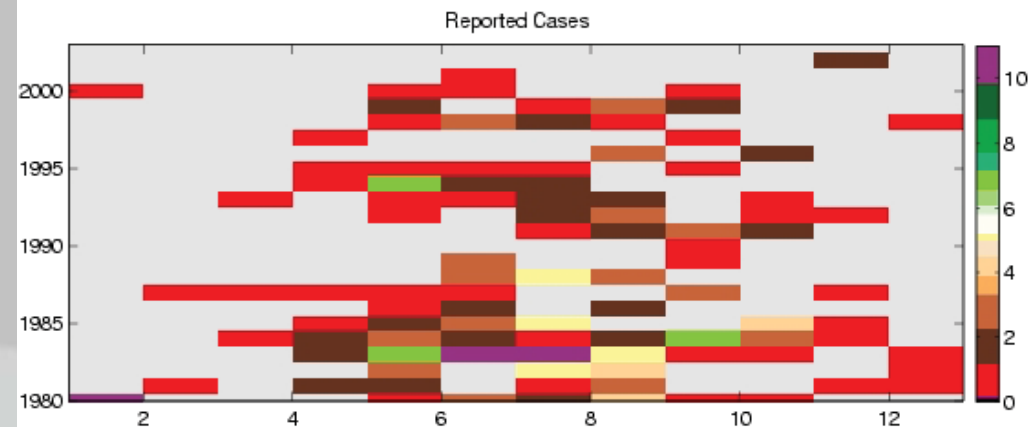
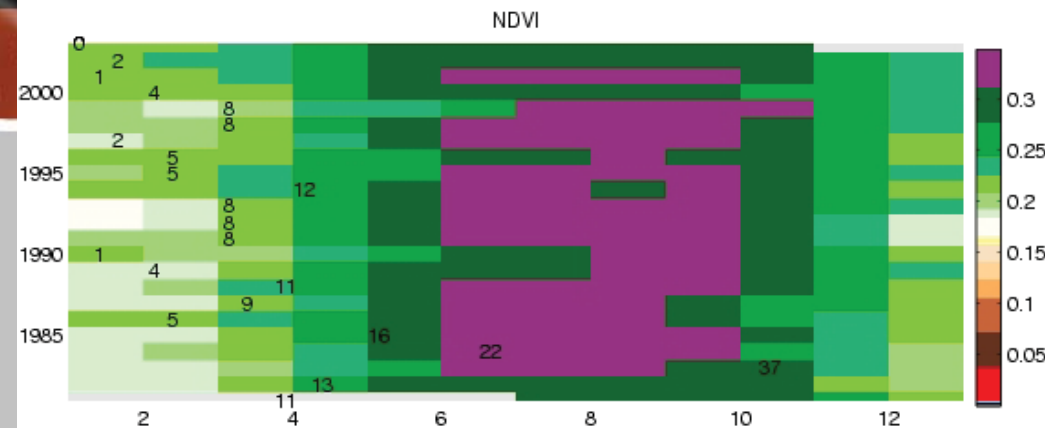


● Locations with reported plague outbreak

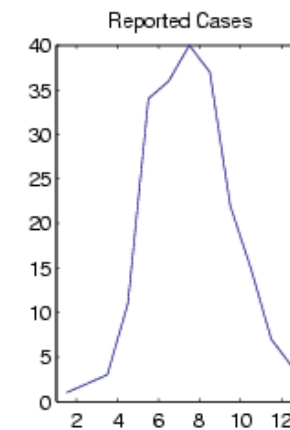
100 0 100 200 Kilometers



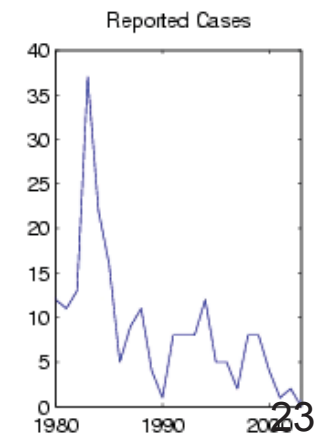
Investigators: C. Tucker; J. Pinzon,  
NASA Goddard



Month

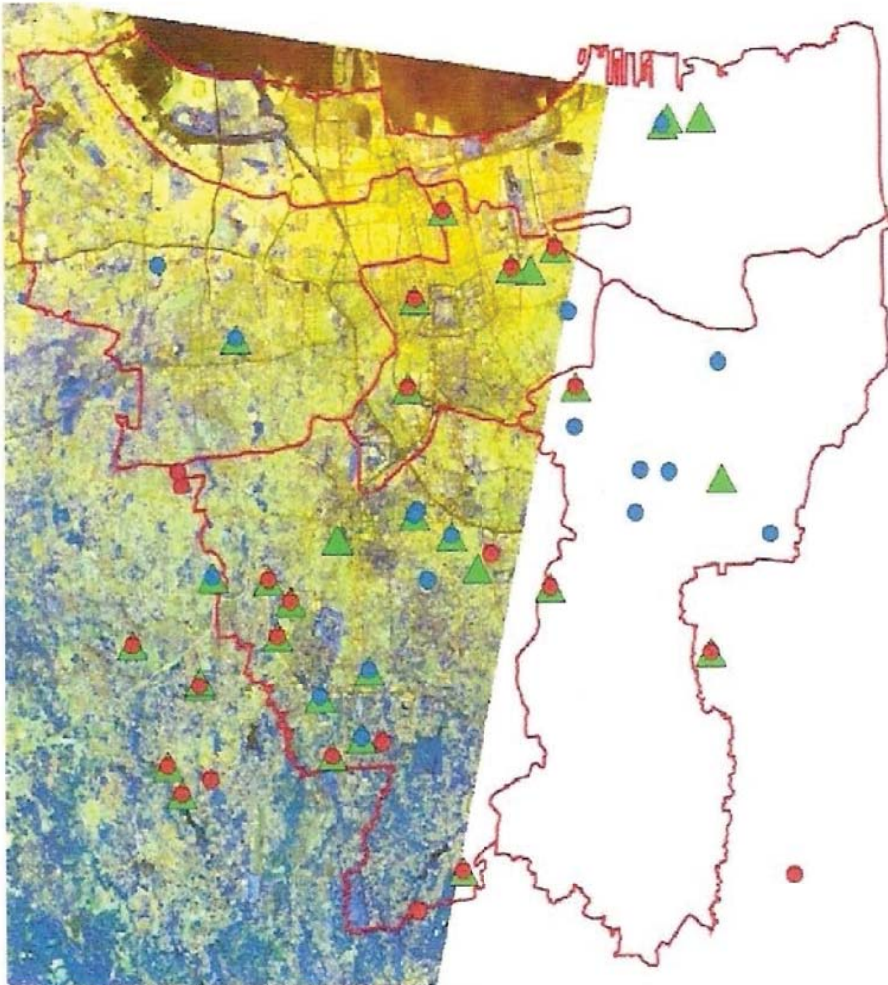


Month



Year

# Collaboration with DOD on Avian Influenza (H5N1)



**Project goal is to enhance the decision support capabilities concerning avian influenza (AI) risks and pandemic early warning through the Department of Defense (DoD) Global Emerging Infections Surveillance and Response System (GEIS) and the Naval Medical Research Unit-2 (NAMRU-2).**

**Environmental parameters such as land cover, precipitation, temperature, and humidity may be key factors in the spread of influenza.**

Poultry and human H5N1 cases in Greater Jakarta from 2005 to 2007 overlaid on a false color NASA Terra ASTER image. ASTER radiances provide land cover information. In the figure, a green triangle is a poultry influenza case, a blue circle is a human influenza case and a red circle is a human influenza death.

# Modeling Global Influenza Risks Using NASA Data

PI: Dr. Richard Kiang, NASA/GSFC

**Project Overview:** The feasibility project utilizes NASA (TRMM, MODIS and GLDAS) and other epidemiological data to examine how influenza circulation is affected by meteorological, environmental or other factors at major population centers around the world through the development of predictive models. The results are shared with public health stakeholders (CDC, WHO EURO, Ministries of Health, and other national influenza organizations) to strengthen their influenza surveillance and response capabilities.

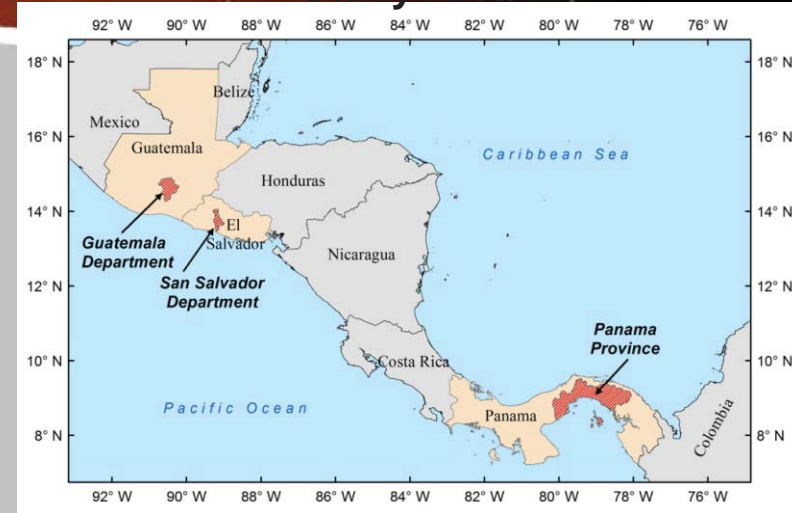
Influenza is responsible for up to 5M severe cases annually across the globe and 500K deaths.

**Results:** Meteorological and environmental factors affect influenza circulation in three aspects – virus survivorship, host susceptibility and transmission efficiency. **Normally low temperature and humidity promote seasonal influenza circulation. However, the project found a positive relationship in Central America between influenza transmission and warm rainy days (i.e., high humidity). This may be due to indoor crowding enhancing transmission.**

Together with CDC, the project held a Climate & Influenza Circulation Workshop for public health stakeholders from Guatemala, Panama and El Salvador. Remote sensing based influenza modeling techniques were taught and practiced in the workshop. A follow-up webinar was held to discuss modeling results and more modeling examples.

Analyses and modeling for the Central American study regions have been completed. A manuscript detailing results, co-authored with 5 CDC and 5 Ministries of Health medical officers, is currently in CDC's clearance process. Analyses of influenza epidemiological and meteorological data for selected regions in Europe, Africa, and Southeast Asia are continuing.

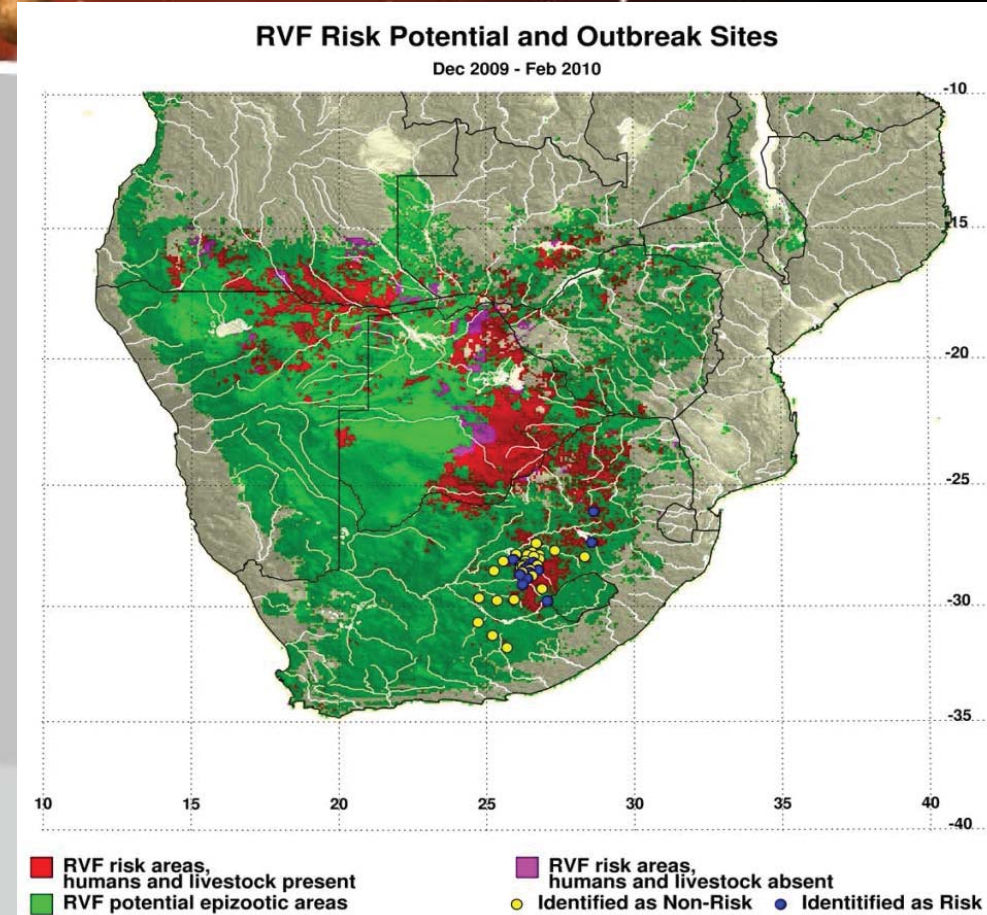
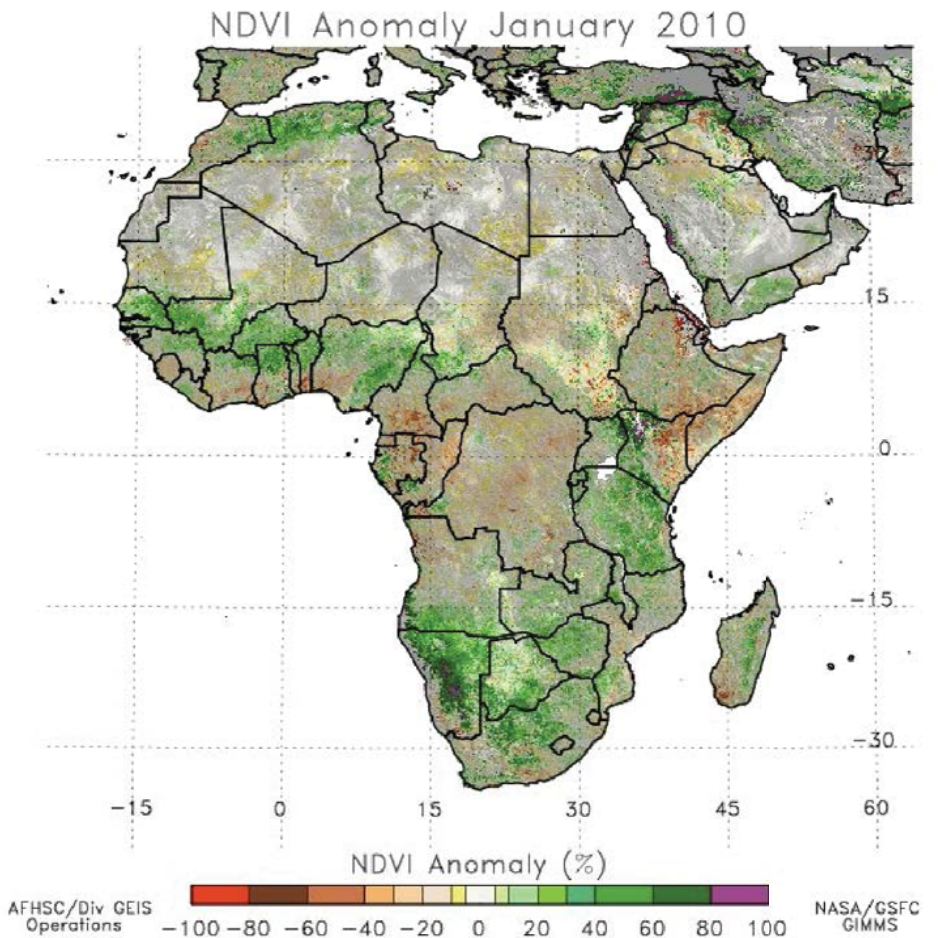
Study Area



Variable increased	by	Changed the weekly influenza-positive sample by
<b>Guatemala Department</b>		
Mean temperature over the past 3 weeks	1° C	2.8 times
Mean rainfall over the past 3 weeks	5 mm	1.6 times
<b>Panama Province</b>		
Mean temperature over the past 3 weeks	1° C	3.4 times
Mean rainfall over the past 3 weeks	5 mm	2.2 times
<b>San Salvador Department</b>		
Specific humidity in the past 4 weeks	1 g/k g	2.5 times



# Collaboration with DOD on Rift Valley Fever in Africa



**Left:** NDVI anomalies for January 2010 are above normal in southern Africa. During December-February rainfall and NDVI were above normal indicating elevated risk of RVF activity for January and February.

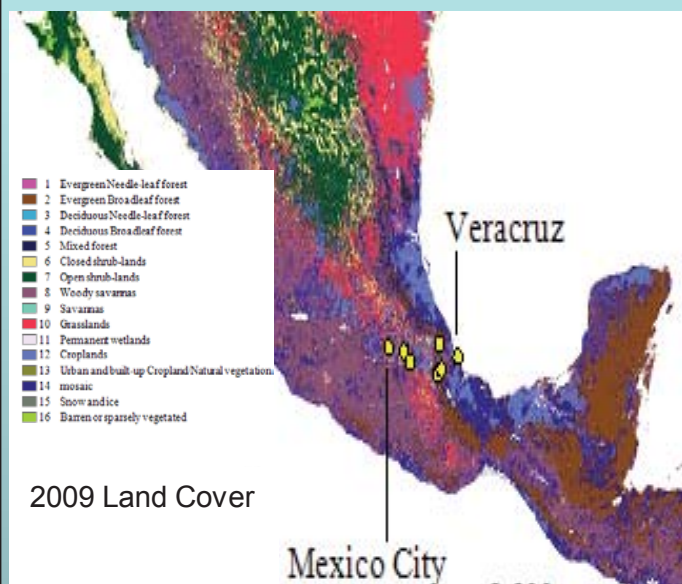
**Right:** Enhanced RVF risk map incorporating livestock, human population data, SRTM digital data, and NDVI resulting in a two-level risk category at regional scale. Confirmed February 2010 RVF outbreaks in South Africa are identified by circles. The advanced awareness on the developing RVF threat gave partners such as WHO and FAO the opportunity to plan and execute disease outbreak prevention, preparedness, and “control-and-response” actions, including advising farmers to vaccinate livestock. Monthly risk maps available at: <http://www.geis.fhp.osd.mil>

# Investigating the Potential Range Expansion of the Vector Mosquito *Aedes Aegypti* in Mexico

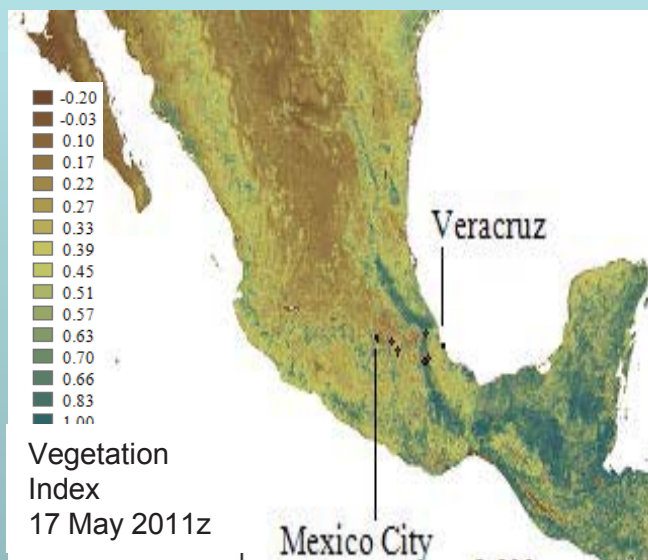
PI: William Crosson, USRA

Employ NASA remotely-sensed data to augment environmental monitoring and modeling. These data -- surface temperature, precipitation, land cover, vegetation indices, soil moisture and elevation -- are critical for understanding mosquito habitat needed for survival and abundance.

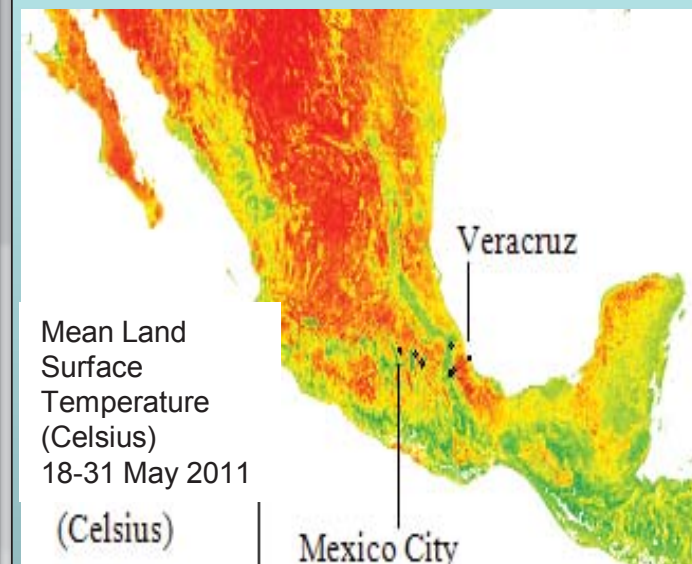
Land Cover (MODIS)



Vegetation (MODIS)



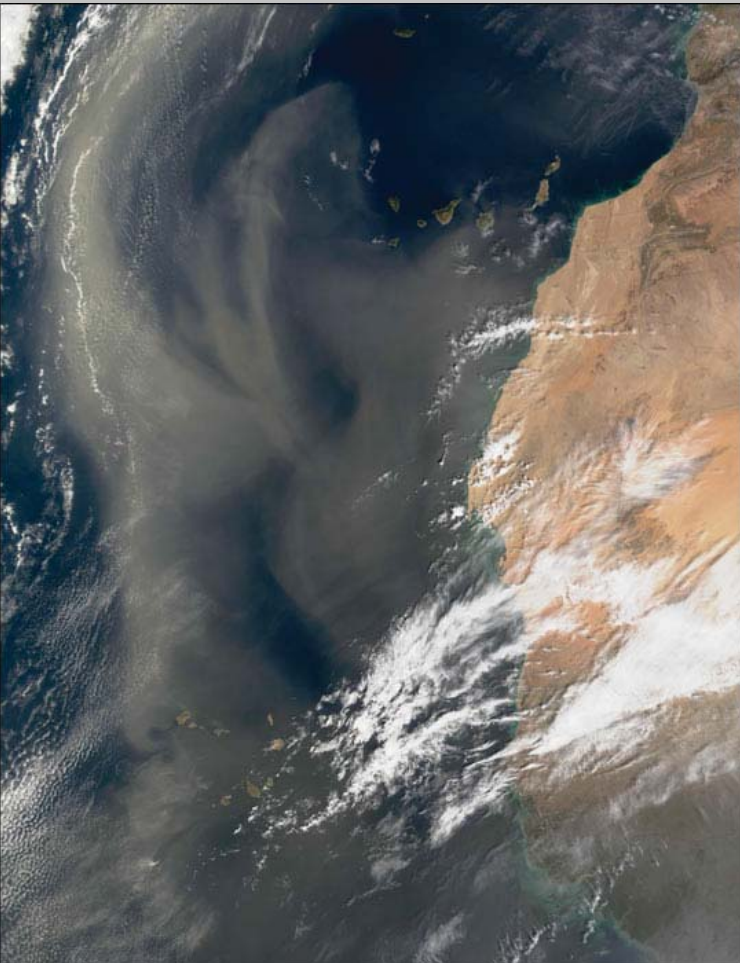
Surface Temperature (MODIS)



Primary end user interest is dengue fever

# Collaboration with Columbia U. on Meningitis in the African Sahel

A large plume of African dust blows out over the Atlantic Ocean. This true color image of the dust event was acquired on February 11, 2002, by MODIS. Particles contained in dust clouds are suspected to be responsible for nasal irritations facilitating meningitis transmission in Africa.



The project is exploring environmental and demographic risk factors as predictors for meningitis outbreaks in the African Sahel, particularly in Niger.

The approach will take advantage of different sources of environmental information: in-situ data, model outputs and satellite observations (including those from the Multi-angle Imaging Spectroradiometer and TRMM). The latter are an important contribution in areas of sparse data coverage, poor real-time reporting, and limited access to reliable environmental information – such as the Sahel.

# Recent Satellites Important for Public Health

- **NPOESS Preparatory Mission (NPP) -- 10/28/11**
  - NPP will serve as a bridge mission between the NASA Earth-observing research satellites Terra, Aura, and Aqua and the operational Joint Polar Satellite System (JPSS) constellation.
- **Landsat Data Continuity Mission (LDCM) -- 2/11/13**
- **Global Precipitation Mission (GPM) – 2/27/14**
  - Will provide accurate observations of the intensity and distribution of global precipitation. GPM builds on the heritage of the TRMM mission and is in partnership with JAXA.



# Future Observations for Health-Near Term

- **Orbiting Carbon Observatory (OCO)-2** – 2014
  - NASA's first dedicated Earth remote sensing satellite to study atmospheric carbon dioxide from Space. OCO-2 will be collecting space-based global measurements of atmospheric CO<sub>2</sub> with the precision, resolution, and coverage needed to characterize sources and sinks on regional scales.
- **Soil Moisture Active Passive (SMAP)** – 2014
  - SMAP will use a combined radiometer and high-resolution radar to measure surface soil moisture and freeze-thaw state.
- *ECOsysteM Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)* ~ 2017
  - ECOSTRESS will provide critical insight into *plant-water dynamics* and how *ecosystems change with climate* via *high spatiotemporal* resolution thermal infrared radiometer measurements of evapotranspiration from the International Space Station (ISS).

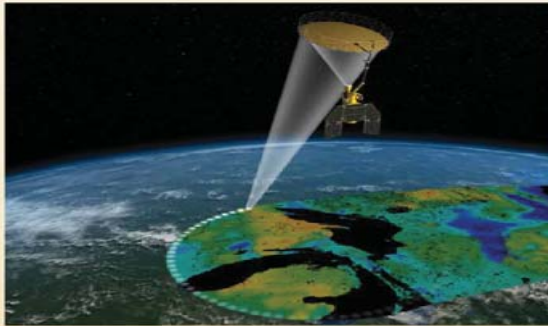




# Soil Moisture Active Passive (SMAP)

## APPLIED SCIENCE

Mapping soil moisture and freeze/thaw state from space



### The SMAP Mission

**Objectives:** SMAP measurements will be used to enhance understanding of processes that link the water, energy, and carbon cycles, and to enhance the predictive skill of weather and climate models. SMAP data will also be used to quantify net carbon flux in boreal landscapes and to develop improved flood prediction and drought monitoring capabilities.

**Observatory:** The SMAP observatory employs a dedicated spacecraft with an instrument suite that will be launched on an expendable launch vehicle into a 680-km near polar, sun-synchronous orbit, with equator crossings at 6 AM and 6 PM local time.

**Instrument:** The SMAP instrument includes a radiometer and a synthetic aperture radar operating at L-band (1.20-1.41 GHz). The instrument is designed to make coincident measurements of surface emission and backscatter, with the ability to sense the soil conditions through moderate vegetation cover. The conically-scanning antenna covers a 1000 km swath providing global coverage within 3 days at the equator and 2 days at boreal latitudes (>45° N).

**Operations:** SMAP science measurements will be acquired for a period of three years. A comprehensive validation program will be carried out after launch to assess the science data products. The products from these activities will be made available through a NASA data archive center.

Area	Likely Mission Applications	Potential Mission Applications
Weather	More accurate weather forecasts; prediction of severe rainfall	Regional weather prediction improvements
Natural Disasters	Drought early warning decision support; key variable in floods and landslides; operational flood forecasts; lake and river ice breakup; desertification	Fire susceptibility; heat-wave forecasting
Climate Variability and Change	Extended climate prediction capability; linkages between terrestrial water, energy, and carbon cycles; land/atmosphere fluxes and carbon (CO <sub>2</sub> ) source/sink activity for atmospheric greenhouse gases	Long term risk assessments
Agriculture and Forestry	Predictions of agricultural productivity; famine early warning; monitoring agricultural drought	Crop management at the farm scale; input to fuel loading models
Human Health	Landscape epidemiology; heat stress and drought monitoring; insect infestation; emergency response plans	Disease forecasting and risk mitigation
Ecology	Carbon source/sink monitoring; ecosystems forecasts; improvements in monitoring of vegetation and water relationships over land	Wetlands resources and bird migration monitoring; cap-and-trade carbon inventory assessment and monitoring
Water Resources	Regional and local water balance; more effective management	Variability of water stored in lakes, reservoirs, wetlands and river channels monitoring
Ocean Resources	Sea ice mapping for navigation, especially in coastal zones; temporal changes in ocean salinity	Provision of ocean wind speed and direction, related to hurricane monitoring
Insurance Sector	More accurate forecasts of weather; prediction of severe rainfall; operational severe weather forecasts; mobility and visibility	Crop insurance programs; flood insurance programs; tourism and recreation
Coastal Inundation	Input to sea level rise products	Maps of coastal inundation; ocean winds monitoring for hurricanes
Drought	Early warning decision support; drought monitor products	Desertification identification
Flood	Improved forecasts, especially in medium to large watersheds; flood mapping; protection of downstream resources; soil infiltration conditions; prediction of ice breakup	Prediction of the impact of tropical storms on hydrology
Ecosystem Health	Improvements in monitoring of vegetation health and change; ecosystem dynamics	Wetlands and bird migration monitoring; Rangeland forage productivity forecasts
Wildfires	Input into fire potential models	Improvements in fuel loading models, especially for non-heavily forested areas

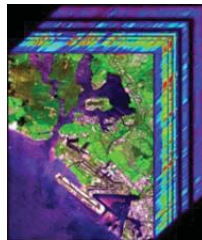
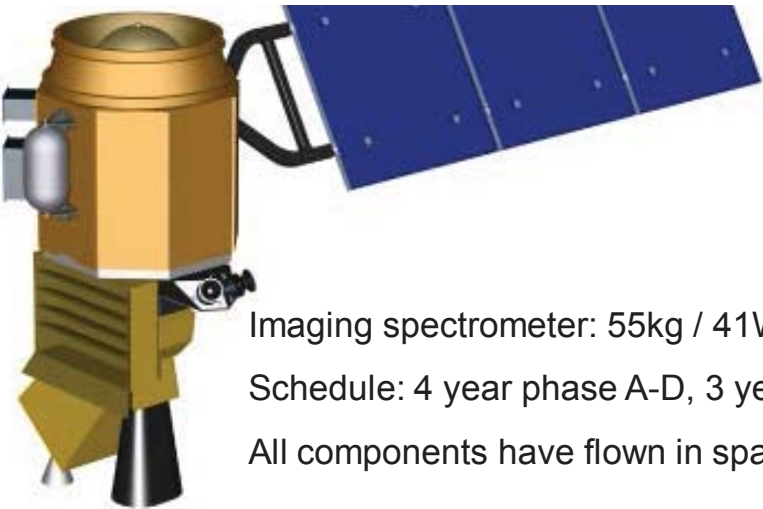
## Public Health

- Landscape epidemiology
- Heat stress & drought monitoring
- Insect infestation
- Emergency response plans
- Disease forecasting
- Risk mitigation

- Global Coverage once every 3 days
- Products for soil moisture & temperature
- 1-36 km resolution
- Nov 2014



# HyspIRI Visible Shortwave Infrared (VSWIR) Science Measurements



Imaging spectrometer: 55kg / 41W

Schedule: 4 year phase A-D, 3 years operations

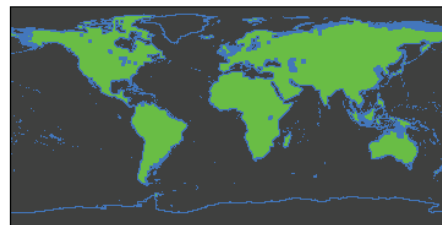
All components have flown in space

## Science Questions:

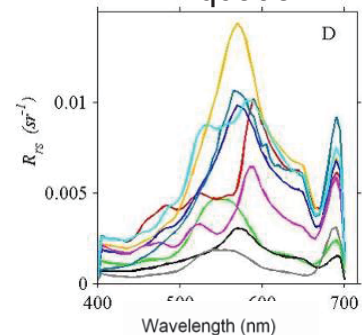
- *What is the composition, function, and health of land and water ecosystems?*
- *How are these ecosystems being altered by human activities and natural causes?*
- *How do these changes affect fundamental ecosystem processes upon which life on Earth depends?*

## Measurement:

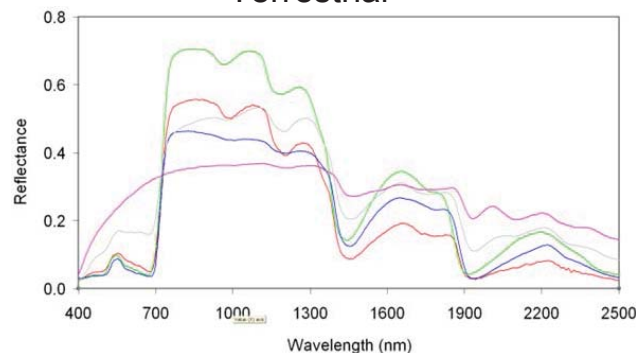
- 380 to 2500 nm in 10nm channels
- Accurate 60 m sampling
- 19 days revisit mapping mission
- Global land and shallow water



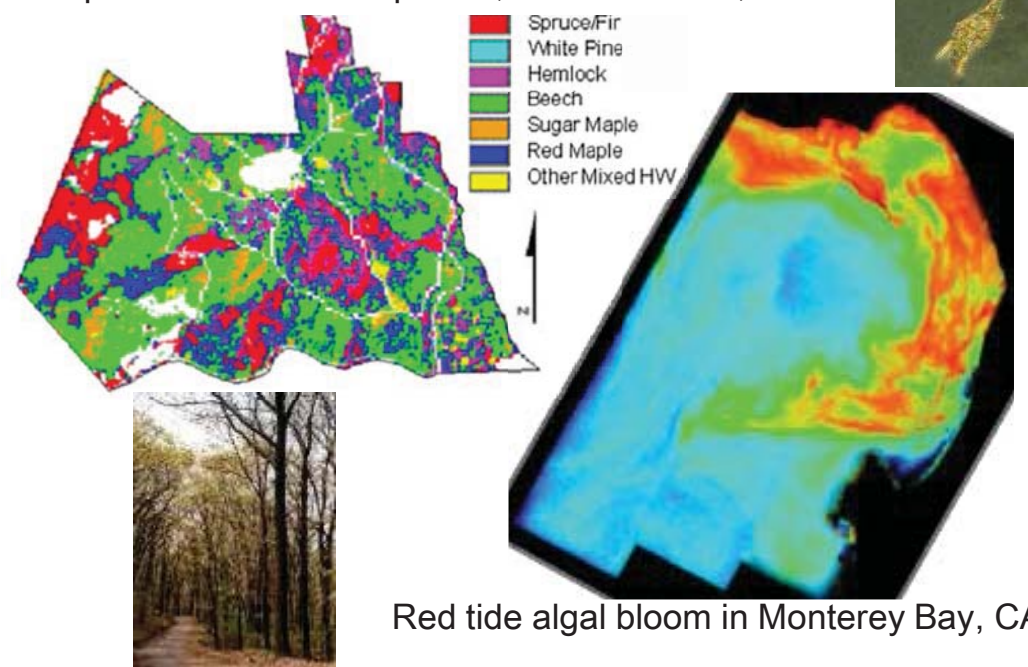
### Aquatic



### Terrestrial



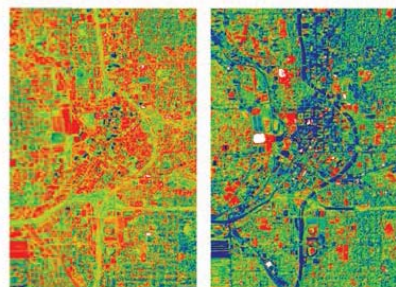
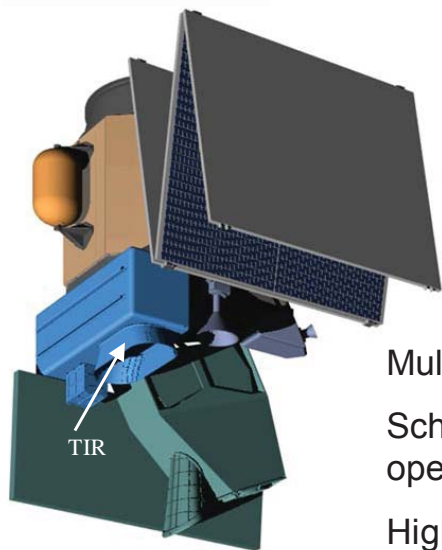
## Map of dominant tree species, Bartlett Forest, NH



Red tide algal bloom in Monterey Bay, CA



# HyspIRI Thermal Infrared Multispectral (TIR) Science Measurements



Temperature  
Albedo  
Atlanta, GA - May 1997

Multispectral Scanner: 60kg / 103W

Schedule: 4 year phase A-D, 3 years operations

High Heritage

## Science Questions:

TQ1. Volcanoes/Earthquakes (MA,FF)

– How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?

• TQ2. Wildfires (LG,DR)

– What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?

• TQ3. Water Use and Availability, (MA,RA)

– How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?

• TQ4. Urbanization/Human Health, (DQ,GG)

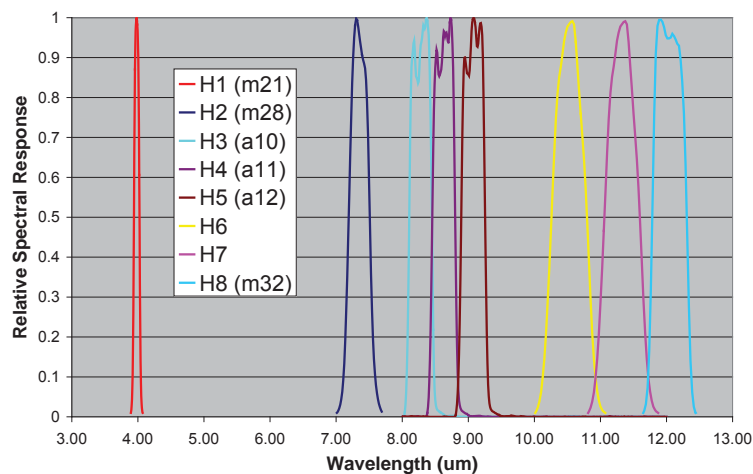
– How does urbanization affect the local, regional and global environment? Can we characterize this effect to help mitigate its impact on human health and welfare?

• TQ5. Earth surface composition and change, (AP,JC)

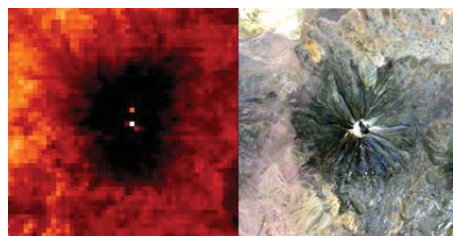
– What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

## Measurement:

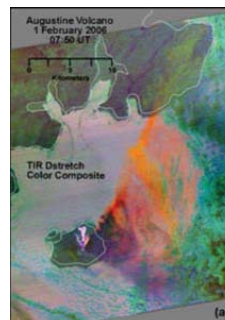
- 7 bands between 7.5-12  $\mu\text{m}$  and 1 band at 4  $\mu\text{m}$
- 60 m resolution, 5 days revisit
- Global land and shallow water



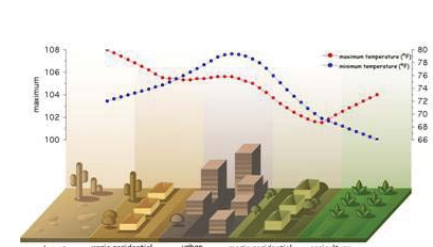
## Andean volcano heats up



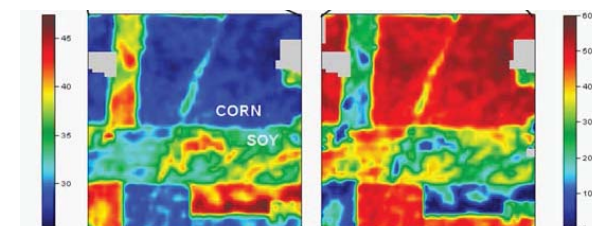
## Volcanoes



## Urbanization



## Water Use and Availability



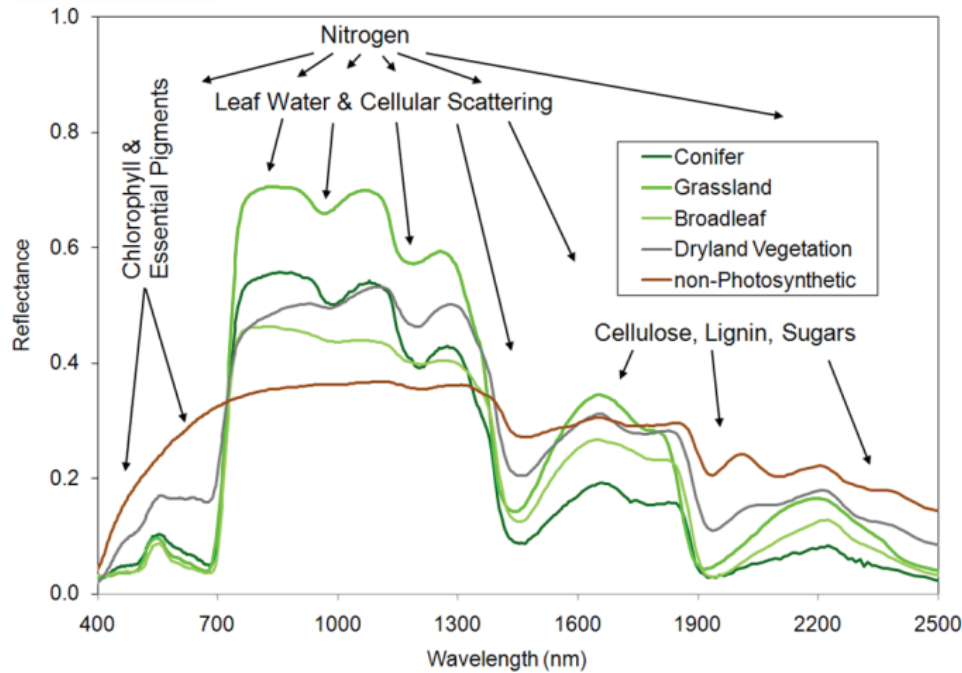
Surface  
Temperature

Evapotranspiration

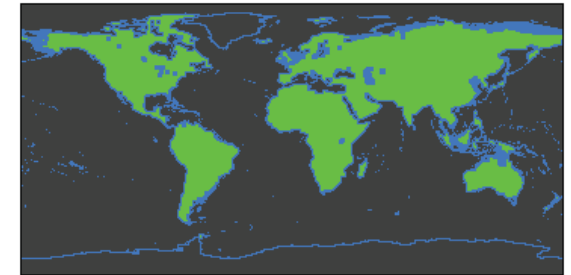
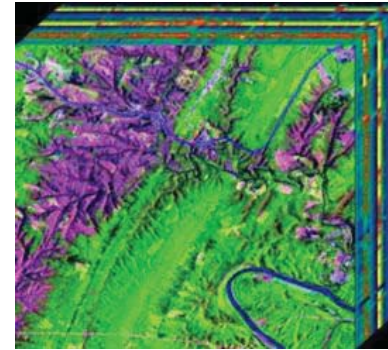


# Ecosystem Measurements for Climate Feedbacks

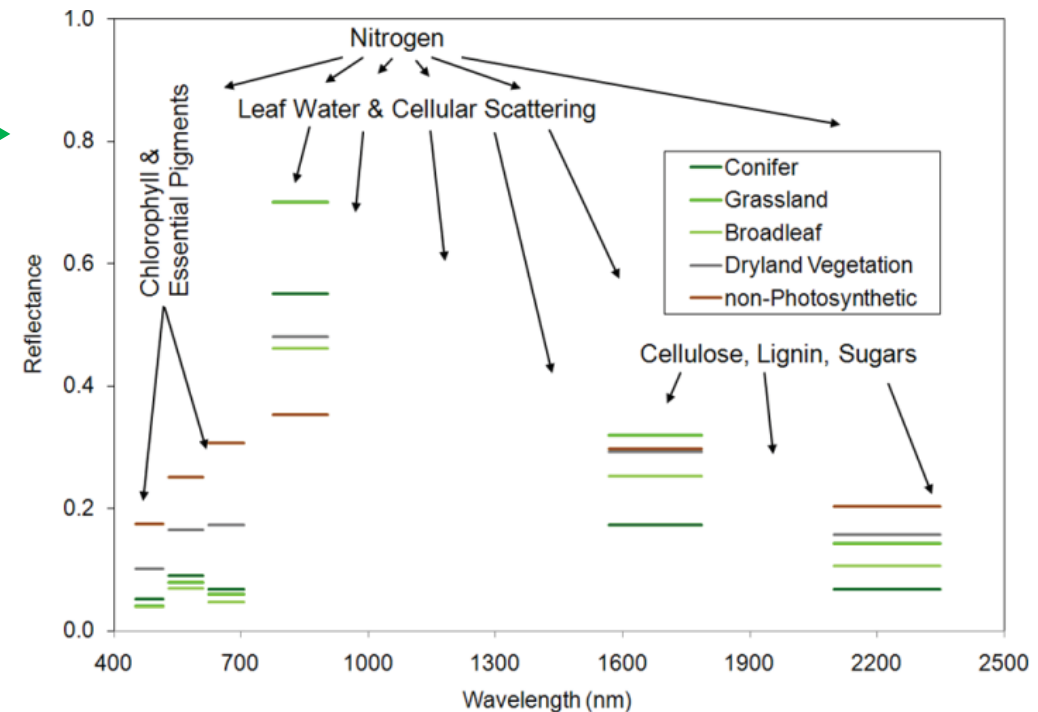
## Measuring the Terrestrial Biosphere



← Imaging Spectroscopy is required to measure critical variables of the terrestrial biosphere.



Multi-spectral imaging is insufficient →





## Strengths Of Satellite Observations:

- Measures environmental variables important to vector life cycles- ppt., soil moisture, temperature, wet/dry edges, solar radiation
- Land use/cover mapping
- Ecological variables – canopy cover, species, phenology, aquatic plant coverage
- Large spatial coverage
- Topography
- Time series





# Challenges

Satellite data – repeat frequency & spatial resolution

- spectral bands available
- clouds
- life cycle
- cost

## Public Health

- availability of data & various sampling issues
- difficulty in getting access to sampling areas
- cost
- understanding of the data provided by satellites



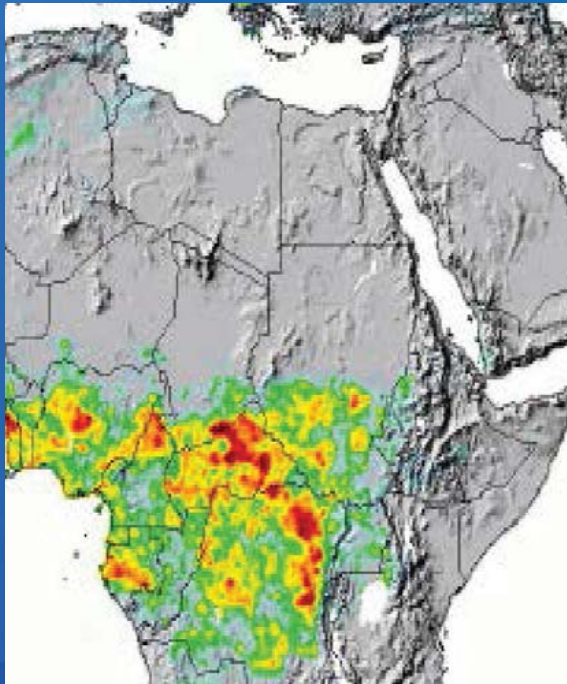


# SERVIR

Regional Platform for Science and Policy  
in the Americas, Africa, and Asia



Using earth observations and predictive models for  
environmental management, disaster response, and  
climate change adaptation.



Flood Forecasting in Africa



Training and Capacity Building



Tracking Fires in Guatemala Mexico



- Data and Models
- Online Maps
- Visualizations
- Decision Support
- Training
- Partnerships



ISPRS Book Series



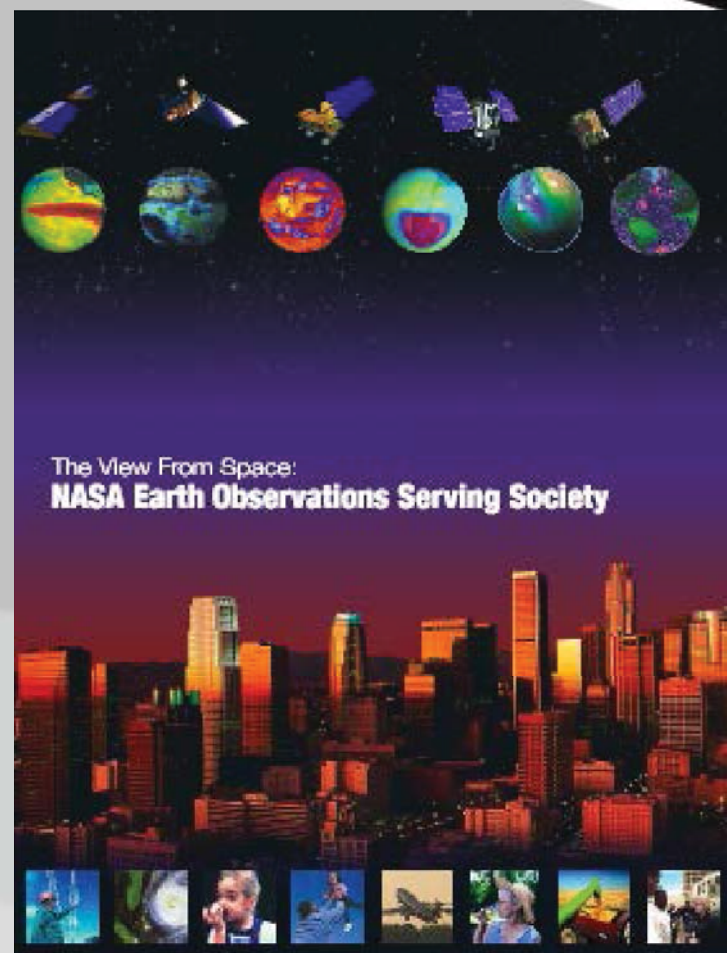
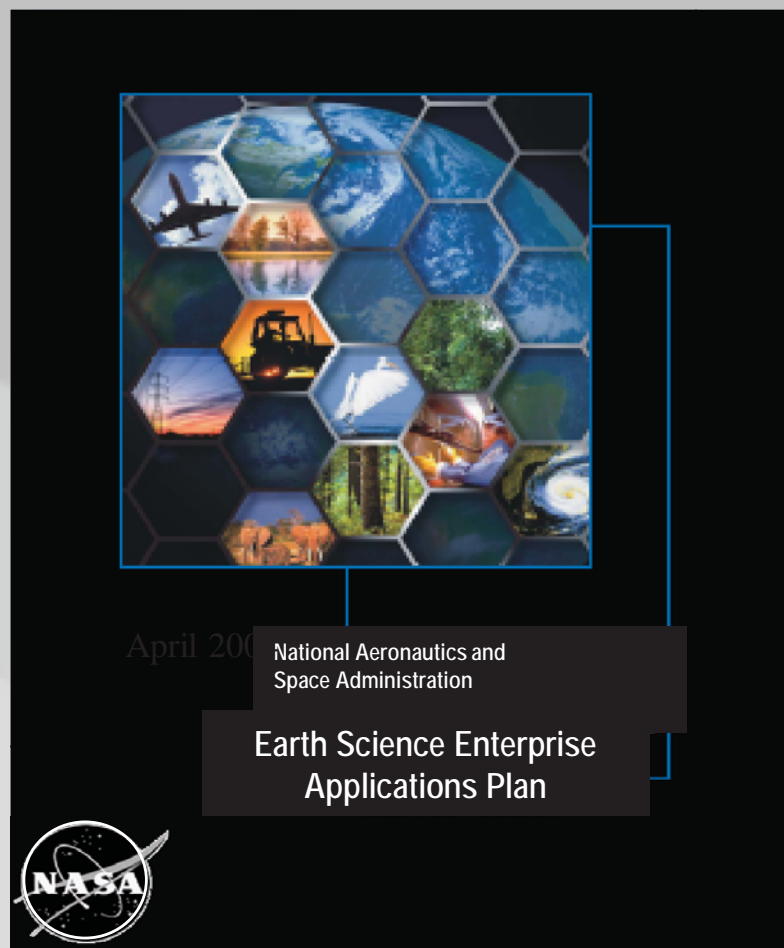
## Environmental Tracking for Public Health Surveillance

Editors: Stanley A. Morain & Amelia M. Budge



 **CRC Press**  
Taylor & Francis Group  
A BALKEMA BOOK

# Applied Sciences Program



<http://appliedsciences.nasa.gov>

[http://weather.msfc.nasa.gov/conference/phconference\\_home\\_sa.html](http://weather.msfc.nasa.gov/conference/phconference_home_sa.html)



# NASA's Public Health Partners

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.gov/rs



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.edu



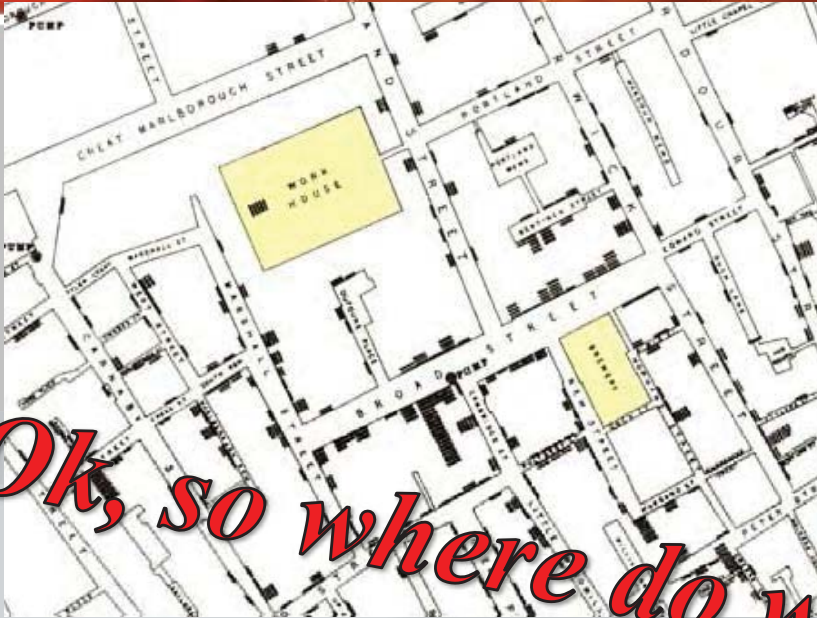
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# Epidemiology in the 21<sup>st</sup> Century



*Ok, so where do we go from here?*

